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WHY IS THERE MUSIC?

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Wien, im Oktober 2010

(Christine Mayer)

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Abstract

How and why music has evolved in human cultures remains an unsolved question even today. Recently a broad discussion has emerged within the related sciences. First, the anatomical prerequisites are considered that make vocalizations possible. Other important facts came from archaeological findings. Possibly the oldest music instrument is a bone flute, found in Slovenia and dated to 50.000 years. (Kunej & Turk, 2000)

The next step will be exploring the different hypotheses about the origins of music. (1) Is it possible that music is an adaptation, or is it rather a byproduct (Pinker, 1997)? (2) If music is an adaptation, are the origins of music caused by sexual, group or kin selection? (3) Is music an analogous trait or a homologous one? For example, did music evolve independently in different species or do we share a common ancestor with primates who were already singing?

I will show that most of the reviewed scientists argue that music is an adaptation caused by group selection and not a byproduct. Fewer scientists argue for music caused by sexual selection – most of them are even against sexual selection. The same is the case for kin selection. Additionally they argue for analogy and against homology. But they are using a lot of different kind of evidence. Most of them used evidence from animals for the origins of music in humans.

These points are still open and unanswered or subject to dispute. Scientists are using different evidence for their argumentation without reconsidering their arguments in other contexts. There is only one universal known in human music: lullabies.

Zusammenfassung

Wie und warum Musik in der menschlichen Kultur entstanden ist, bleibt eine ungelöste Frage. Diese Frage hat in den betreffenden Wissenschaften eine große Diskussion ausgelöst. Zunächst werden die anatomischen Vorrausetzungen betrachtet, welche eine Vokalisierung erst möglich machten. Ebenfalls wichtig sind archäologische Funde, wobei der wichtigste und zugleich älteste Fund eine etwa 50.000 Jahre alte Knochenflöte ist, welche in Slowenien gefunden wurde. (Kunej & Turk, 2000)

Der nächste Schritt wird sein, die verschiedenen Hypothesen, zur Entstehung der Musik zu ergründen. (1) Ist es möglich das Musik eine biologische Adaptation ist oder ist sie nur ein Nebenprodukt (Pinker, 1997)? (2) Wenn Musik eine biologische Adaptation ist aufgrund welches Selektionsmechanismus ist sie entstanden. Ist sie aufgrund von sexueller, Gruppen-, oder Verwandtenselektion entstanden? (3) Ist Musik eine analoge oder homologe Entwicklung? Hat sie sich unabhängig in unterschiedlichen Spezies entwickelt oder teilen wir einen gemeinsamen Vorfahren mit Primaten, welcher schon singen konnte?

Ich werde zeigen, dass die meisten Wissenschaftler dafür argumentieren, dass Musik als Adaptation entstanden ist und nicht als Nebenprodukt. Zusätzlich plädieren mehr Wissenschaftler dafür, dass Musik durch Gruppenselektion entstanden ist und nicht durch sexuelle oder Verwandtenselektion. Mehr von ihnen argumentieren sogar gegen die Entstehung durch sexuelle Selektion. Auch meinen mehr Wissenschaftler, dass Musik eine Analoge und keine Homologen Entwicklung ist. Jedoch benutzen sie unterschiedliche Grundlagen für ihre Argumentationen, wobei die meisten auf Tiere zurückgreifen.

Die einzelnen Punkte sind immer noch unbeantwortet und führen zu Diskussionen. Wissenschaftler verwenden unterschiedliche Grundlagen für deren Argumentation, ohne ihre Argumente in anderen Kontexten zu überdenken. Darüber hinaus kommt nur ein Musikstil weltweit vor: Schlaflieder.

1 Introduction

How and why music has evolved in human cultures remains an unsolved question even today. Recently a broad discussion has emerged within the related sciences. This work will give an overview of previous investigations and current research. The questions covered here deal with the fundamental evolutionary processes that caused the development of music in humans.

In spite of this evidently broad discussion about the evolution of music and the variety of different opinions in the literature, nevertheless there are very few experiments on the evolution of music and thus hardly any actual data available. There is also little sense of direction. Scientists of various fields proffer a lot of criteria for different hypotheses but do not try to support inference through research. How can we obtain more clarity about the evolution of music?

First I will look at previous investigations to get an overview of the current state of research, the rhetoric of miscellaneous views and arguments across different fields and scientists. I am going to identify relations, contradictions, gaps and inconsistencies in the literature generally and in the sciences' specific arguments. If any questions about the evolution of music have actually been answered, I will note these, too.

The first interesting point in the evolution of music is trying to get an overview of the different definitions of music. There is no consistent definition for music; it seems as though every scientist or group of scientists work with a different definition.

The next step will be a short overview of the anatomical prerequisites that are needed to produce or perceive music. I will explore how these prerequisites developed over the evolutionary history of humans. Afterwards I will give an overview of animals, which have communication signals that are similar to the music of humans. This is followed by a summary about the propagated functions of human music, including the importance for mother-infant communication.

Then I will focus on the important questions of the evolutionary fundamentals of the development of human music. Could it be that music is a product of adaptation? If this is the case, by which selection process was the development of music caused? There are three different theories I am going to explore. The first one will be the assumption that music is caused by sexual selection. The other two are the processes of group selection and kin selection. But there is another possibility for the development of human music; it could be a byproduct of another adaptation, like language.

Afterwards I will compare the different aspects, for homology and analogy, systematically. Data may support the hypotheses, or not, may help to identify relations or contradictions between the different hypotheses, and may also help to find gaps and inconsistencies in the literature.

1.1 Definition of music

The first question arising in connection with the evolution of music is: “What is music?”. This has been controversial for a long time.

How has today’s word “music” emerged? The Concise Oxford Dictionary of English Etymology describes music as an “art of combining sounds in a certain order for aesthetic effect”, and also as “sounds in melodic or harmonic combination”. The dictionary further notes that the English word music evolved from the French word “musique”, which came from the Latin word “mūsica”. The Latin word arose from the Greek word “mousike”, meaning, concerning the arts of the muses (The Greek word for muse is moûsa). ("music," 1996)

1.1.1 Components

A short definition, which probably does not catch all aspects of music, and only deals with music of the Western society, would be a tonal variety of notes with specific pitches, intervals and characteristic timbres combined into phrases. These phrases could be more or less repeated and put together into series with a specific meter and rhythm, so as to result in a song or melody. It seems that every culture has music that includes a meter, pulse and at least three or four pitches (Falk, 2009). (Marler, 2000)

A song is a series of different notes, arranged and related to each other in such a way as to form a recognizable sequence (Thorpe, 1961). This arrangement of notes has to be nonrandom.

Furthermore notes are discrete events, which have to have beginnings, ends and a target pitch or coloring. This feature of music differentiates it from other streams of sounds such as a howling wind, an engine roar or the intonations of speech. The only universal component of music is rhythm, which is displayed in dancing, nodding, shaking, swinging, clapping or snapping to music. (Pinker, 1997)

All music is built on a discrete set of pitches that are called a scale (Nettl, 2000). From this scale, notes are chosen to create a melody.

Music has two main dimensions, which are pitch and rhythmic structure. There are pitches, which are organized into scales, and also syntax for putting them into sequences. This syntax adjusts the harmonic structure, which further affects our expectations of what should come next. It is possible to compare this with poor spoken grammar, which is implicitly “corrected” by the listener. (Falk, 2009)

Octaves are perceived similarly in every culture. All scales in the world are made up of seven or fewer pitches per octave. Each culture chooses a number of oppositional pitches from a sound continuum, which further build a musical scale. Also, emotional excitement is expressed similarly in all cultures through loud, fast, accelerating and high-registered sound patterns. (Brown et al., 2000)

Music is further often described as a combination of complex structured notes, which are, directly or indirectly, produced by humans and vary in pitch, timbre and rhythm (Mithen, 2005). McDermott and Hauser (2005) define music as a combination of notes in hierarchical structure, which allows a large variation. An unlimited number of hierarchically structured signals could be created by combination of a limited number of syllables and notes (Merker, 2002).

Arom (2000) mentioned that it would be important to build a list of criteria of universals specific to music. He suggests the criterion of intentionality, because all music involves an act of intentional construction.

So maybe there is no answer to the question “what is music?”. For nearly every defined feature of music, it is possible to find a musical style which lacks those properties (Brown, et al., 2000).

1.1.2 “Style” and Function

It has often been noted that music is culture dependent (Falk, 2009; Mithen, 2005), and it seems that everyone most enjoys the musical style they grew up with (Pinker, 1997).

But musical style has a large variation in complexity across historical periods, cultures and subcultures. According to Pinker (1997) it communicates only formless emotion. Further, notes are drumbeats with different timbres or pitches, which are not placed in specific intervals. In many musical styles, notes are tones of a fixed pitch that we label as “do, re, mi,…”. A pitch can be defined by an interval between pitches or in comparison to a reference pitch, but not in absolute terms. (Pinker, 1997)

Music is often made to express emotions or to entertain people (Mithen, 2005). Additionally, Fitch (2006) defines music for animals and humans as complex, learned vocalization. He defines complex vocalization as more complex than innate vocalizations in our species, but he also assumes that there is no absolute threshold for complexity.

1.1.3 Relation to speech

Music, as language, also contains complex sound patterns, which vary over time (Falk, 2009). Music is similar to language in the sense that a particular acoustic stimulus in most members of a cultural group is recognized as music, even if these sounds have never been heard before. On the other hand, stimuli such as a wrong note in a melody are recognized by almost everyone as unmusical. (Hauser & McDermott, 2003)

Music is also describes as “heightened speech”, because some singers only “talk on pitch” instead of carrying a melody. As an example, note Bob Dylan, Lou Reed, or Rex Harrison in My Fair Lady. Pinker (1997) describes this sound as “halfway between animated raconteurs and tone-deaf singers”. An example for a musical style in that manner is rap music. Yet a song is composed of a discrete set of pitches, while speech consists of continuously variable pitches, which makes music more acoustically predictable than language (Fitch, 2006).

One feature is shared between language and music – pitch structures are transposable. A word or a song is the same, even if it is performed at a higher pitch. It is also the same whether a man or a woman performs, even though they have different pitch ranges. (Fitch, 2006)

Additionally music is composed of a discrete set of notes and beats (Fitch, 2006). These do not have semantically discrete meanings. Fitch (2006) mentions that this sort of meaninglessness leads to the absence of arbitrariness, to displacement and to a combination of meaningless elements into meaningful words. For language, for example, a phoneme itself has no meaning, but if certain phonemes are put together, the result is a meaningful word. This is not the case for music – neither a note like an “A#” nor putting various notes together has any meaning. Music is more than putting notes together to create a meaning, or even transporting emotions. It requires further components, such as rhythm, melody or harmony. Fitch also refers to Hockett (1960), whose framework describes music as “speech minus meaning”. This difference between language and music is a very important one, but does not imply that music has no meaning. It only implies that music and language are quite different, caused by different signals and interpretations. In summary, music is like language without propositional, combinatorial meaning. Additionally Fitch (2006) noted that “music expresses the emotions”.

So maybe, the only possible definition for music is, as Bruno Nettl (2000) claims, “human sound communication outside the scope of language”.

1.1.4 Relation to body movements

Fitch (2006) describes instrumental music as the use of body parts to produce sound, and also by manipulating additional objects.

According to Mithen (2005) “bodily entertainment” is an important attribute of music. As “bodily entertainment” he considers tapping fingers or toes and also moving the whole body. So he uses the word “music” to describe both sound and dance. This way to describe music comes closer to the way many traditional societies understand music. For example in Africa, music one cannot dance to, is not regarded as music, but rather as a type of signal device (Arom, 2000).

Possibly, as Mithen (2005) said: “music is partly in the ear of the beholder”.

1.1.5 Discussing the definitions of music

Sometime it seems that all scientists who study music have different definitions for music. But there are a few structures that are important in music. So some scientists (Brown, et al., 2000; Falk, 2009; Marler, 2000; Pinker, 1997) mentioned that every kind of music has some pitches, a meter and a pulse. They also claim that music has to have a specific rhythm. It seems that there are musical components which are universal to every culture. But does this apply also to atonal music, like the music from Schönberg? This seems an unsolved question, because nobody mentioned anything of atonal music. Further they agree that music consists of pitches that are organized in scales (Brown, et al., 2000; Falk, 2009; Nettl, 2000). But these scales seem to differ in their numbers of pitches from culture to culture.

Fitch (2006) defines song as complex, learned vocalization. But there is a problem with this definition. It is indeed possible to measure whether something is learned, but what is complex? Fitch (2006) himself conceded that there is a problem with the word “complex” in his definition, because, according to him, it is not possible to measure if something is complex. Additionally, how complex does something have to be to be music? Here it seems that he defines music, with a word – complex – which again has, in this context, no plausible definition.

The next problem arising is: where the differences are between music and language? There are a lot of similarities between music and language. But there have to be some differences, because humans recognize music as music and language as language. There are no discussions about the fact that we are able to differentiate music from language. One difference mentioned is that music consists of a discrete set of pitches and language, in contrast, of continuously variable pitches. That makes music more acoustically predictable than language (Fitch, 2006). Additionally Besson (1998) figured out, as described later, that melody and lyrics are processed differently in the brain, because it seems that words show different event-related potentials (ERP) in the brain than melodies. So it seems that music and language are processed differently in our brains.

Another fact is that it is sometimes claimed, that music consists of singing, dancing and instrumental music. As Arom (2000) noticed in Africa music that nobody can dance to is not music. This is difficult to say, because this fact could be an individual one.

So there is no possible universal answer to the question, what is music. But as there are some universals like pitches, meter and pulses, it cannot be the case that music is only “in the ear of the beholder (Mithen, 2005)”, because this is not a definition someone can work with. It would be helpful to find a universal definition of music, but this could be complicated. For every definition, someone would find a musical style that lacks those properties.

1.2 How music has evolved

Brown (2000) mentioned that language and music share phonological and syntactic properties. He reported five basic evolutionary possibilities by which music and language evolved (Figure 1).

(1) The model of “parallel evolution” of music and language. In this case music and language could not have any development similarities.

(2) The “binding model”. This model propagates that music evolved from a kind of “Protomusic” and language from a kind of “Protolanguage”. The similarities between both evolved from a later interaction between the

two modules, so that musical properties transferred onto language and vice versa.

(3) The “music outgrowth model”. This means that language evolved from a kind of “Protolanguage” and music is an outgrowth of this process.

(4) The “language outgrowth model”, where music evolved from a kind of “Protomusic” and language is an outgrowth of this process.

(5) The “Musilanguage model”. In this case music and language evolved from a common ancestral form called “Musilanguage” and later split up into two independent processes.

Brown’s (2000) favorite is the “Musilanguage model”, because music and language have too many similarities, to have evolved independently from each other. He prefers this model, because it “simplifies thinking about the origins of music and language”. This model uses common features as a beginning. The “Musilanguage model” has three stages, which qualify it as a precursor for music and language. The first stage includes “lexical tones”, which he describes as “use of pitch to convey semantic meaning”. This contains a design for a tonal system, based on level tones – “discrete pitch level”. The second stage involves “combinatorial formation of small phrases”, which means a combination of lexical tones to melodic and rhythmic units, “expressive phrasing principles” and “use of local and global modulatory devices to add expressive emphasis and emotive meaning to simple phrases”.

Additionally the “Musilanguage model” evolved from referential emotive vocalizations, which is a class of primate calls. This call provides a response to something in the environment. Each call type indicates a special object. This is an important kind of communication for a social group. Further each call has two meanings, an emotive one and a referential one. (Brown, 2000)

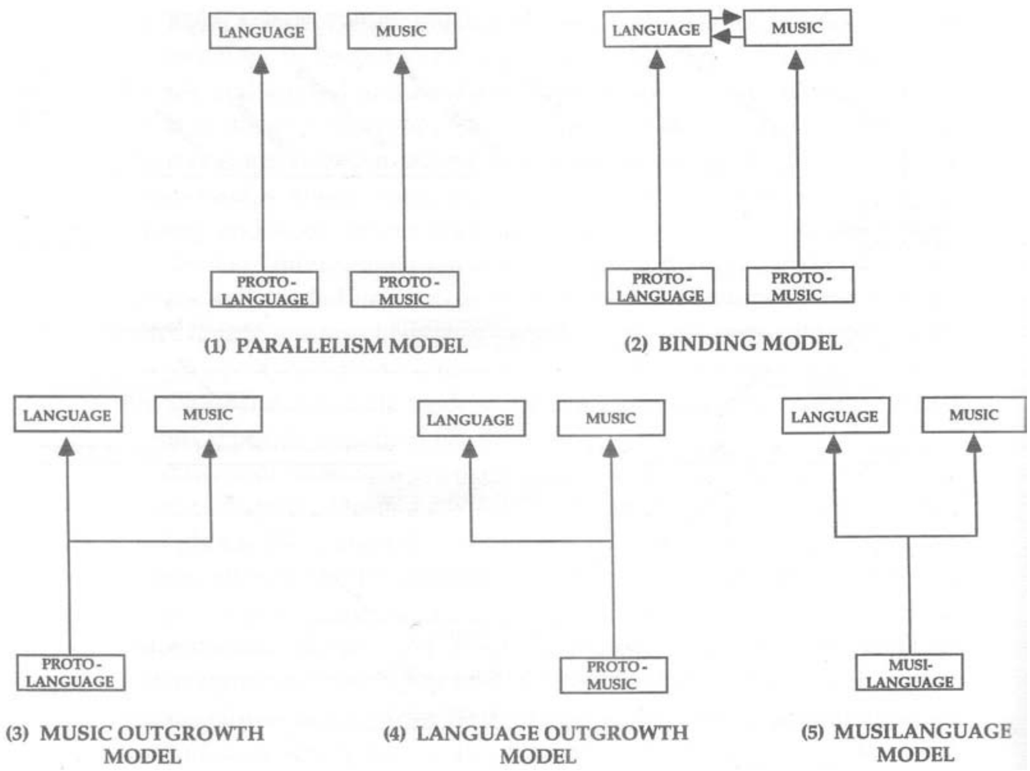

Figure 1: Brown's (2000) models of the evolution of music and language

Mithen (2005) illustrates in his book “The Singing Neanderthal” another model from that music and language could evolved. This model he called “Hmmmmm”. The “H” in this term stands for “Holistic”, which means that expressions are not organized in words and ruled by a kind of grammar, but were complete, independent, multi-syllabic statements. The first “M” means “manipulative”, which he describes as messages that were used to get someone are doing something. The next two “M” stand for “multi-modal”. This implies that not only vocalizations were used, but also gestures. The next-to-last “M” is “musical”. Rhythm and prosody were more important than synchronization and turn-taking. “Mimetic” the last “M” means that mimicry also was involved in communication, to display objects of the real world.

1.2.1 Anatomy background

To analyze the development of human music, it is important to look at the anatomical prerequisites. These are the bony structures in modern humans and the development of them in our ancestors. They yield important information about the time of the first appearance of music in humans.

To produce vocalizations, humans use the supralaryngeal tract and the oral cavity. In the supralaryngeal tract the acoustic energy of the vocalizations is created by the larynx. The larynx modulates the airflow in the throat. The sound created is further influenced by the movement of the tongue, lips, teeth and the palate in the oral cavity. (Morley, 2002)

The difficulty in studying the anatomical structures which are required for vocalization is that most of them consist of cartilaginous and soft tissue. These structures are not preserved in the fossil record. So it is necessary to draw conclusions from the bony structures to study the ability for vocalization in our ancestors. The bony structures preserved in the fossil records are jaws, the bottoms of the skulls and sometimes the hyoid bones. (Morley, 2002)

The position of the larynx in the throat, the size of the mouth and the size and the mobility of the tongue all have an enormous impact on vocal ability. Primates have limited vocal abilities, because their larynx is positioned relatively high in the throat. This limits the resonance, which is produced by the pharynx. In contrast to primates, the larynx is positioned lower in the throat in adult humans. This allows the production of a wider range of vowels, because of a larger pharyngeal resonance cavity. These vowels, like [a], [u] and [i], are universals in human languages. (Morley, 2002)

There is a correlation between the position of the larynx, the tongue, the origins of the laryngeal muscles of the cranial base and the degree of the curvature of the bottom side of the skull base, which is called basicranial flexion (Laitman et al., 1979). The basicranial flexion can be used to reconstruct the angle of inclination of the styloid process, which is a bony structure on the temporal bone at the skull base. This is helpful in identifying the position of the hyoid bone and the larynx, because the muscles which support these structures attach to the styloid process. So it is possible to reconstruct the vocal tract of our ancestors. The first sign of a curvature of the skull base is found in the *Homo ergaster* skull KNM-ER 3733, which was found at Koobi Fora, Kenya. This skull is 1.75 million years old.

A fully curved skull base is first seen in *archaic Homo sapiens*, or *Homo heidelbergensis*, who lived 400,000 to 300,000 years ago (Laitman, 1984). Probably

Homo heidelbergensis was able to exploit the full repertoire of vowel sounds, like modern *Homo sapiens*. In contrast, Laitman (1979) found that the base of the skull of a Neanderthal is much longer and flatter, which in turn implies incomplete speech.

Another important consideration is the *hypoglossal canal*, through which the *hypoglossal nerve* passes – the twelfth cranial nerve. This nerve innervates, among others, the muscles of the tongue. The size of the channel could be closely related to the mobility of the tongue. The relative size of the channel in *Australopithecus afarensis* and *Homo habilis* is comparable to that of chimpanzee (*Pan troglodytes*) and gorilla (*Gorilla gorilla*). In *Homo neanderthalensis*, *Homo heidelbergensis* and *early Homo sapiens* the channel has approximately the same size as in modern humans and is even larger than, for example in chimpanzees. Thus one can assume that the development of the mobility of the tongue, like in modern humans, occurred in *Homo heidelbergensis*, about 300,000 years ago. (Morley, 2002)

The *hypoglossal* and *vertebral canals*, in Neanderthals, show evidence of motor control over their tongues and breathing similar to that of modern humans. This is also the case for sound perception. (Mithen, 2005)

The anatomical differences between the early hominids and the modern-day apes raise the possibility of a more diverse range of vocal sounds. One important difference is the reduction of the size of the teeth and jaws, caused by a change of the dietary trend towards meat-eating. This led to a change of shape and volume of the final section of the vocal tract. The reduction of the teeth and jaws make possible a different range and a greater diversity of oral gestures. Another development which changed the vocal tract was bipedalism, because of a more upright stance. (Mithen, 2005)

The low larynx was a consequence of anatomical adaptations for bipedalism. The spinal cord had to enter the brain case from below and not from behind. So there was less space between the spinal cord and the mouth for the larynx. The space was further reduced by changes in the face and dentition, as explained above. The consequence of bipedalism was that the larynx got positioned lower in the throat, leading to a larger vocal tract. (Aiello, 1996)

Further, *Homo ergaster* had no anatomical adaptations for fine breathing control, which is important for complex vocalizations. *Homo ergaster's* ability to regulate breathing does not differ from that of African Apes today.

1.2.2 Brain on music

It is also important to get an overview of the abilities our brain has to process music. I am going to explore this on the next few pages.

It is difficult to study the evolutionary history of these systems because there are no direct fossil records of early human brains. To study early human brains, endocasts are used. An endocast shows the outer surface of the brain, but not the internal brain structure and only a little bit about the connections between the different areas. However it is possible to analyze the brain's shape and so identify the development of, for example, Broca's area. The first evidence for development in Broca's area was shown in *Homo habilis*, KNM-ER 1470, from East Turkana (Falk, 1992), which led to the assumption that *Homo habilis* possibly had some language abilities. But language ability is not localized only in the Broca's area and areas nearby; also, Broca's area is used for other processes than language. (Morley, 2002)

According to Mithen (2005) the brains of early Homo possibly show the first evidence of the evolution of Broca's area. Broca's area could be homologous with area F5 in monkeys. The further development of area F5 to Broca's area could have happened because of an enhanced number and use of mirror neurons. This could be evidence that Homo possibly did not use mirror neurons only for imitation of nonverbal gestures, but also for imitation of oral gestures.

It is possible to study how our brain processes music. During the processing of harmony, there is more activity in the left hemisphere of the brain. But the processing of melody requires both cerebral hemispheres, while rhythm shows activation in few brain areas outside of the cerebellum. Melody and harmony also activate areas of the cerebellum, but with less intensity. (Mithen, 2005)

Each musical component also shows activation in the frontal cortex. The strongest activation for rhythm was the superior region of the frontal cortex, while melody activated more of the inferior region, and for harmony the activation was somewhere between. (Mithen, 2005)

Peretz and Kolinsky (1993) reported about a patient, C.N., who has a severe impairment of melody processing after brain damage. But he has no problems with rhythm processing. They concluded that melody and rhythm might not processed by the same mechanisms in the brain, but rather by two systems. This led to the assumption that melody and rhythm have separate functional and behavioral roots, which later get used together in musical performance (Morley, 2002).

Musicians with perfect pitch show left hemisphere dominance during music perception (Hauser, 2000). Both hemispheres are involved in the production and perception of rhythm, but it seems that the left hemisphere is more dominant for ordering of temporal information, which is important for processing rhythm. In contrast, pitch perception shows a left ear, and hence a right hemisphere, dominance. (Morley, 2002)

The *planum temporale* of musicians with perfect pitch is larger in the left hemisphere than the right (Schlaug, Jäncke, Huang, & Steinmetz, 1995). But the *planum temporale* is larger in the right hemisphere in musicians without perfect pitch and in non-musicians. This area is also larger on the left hemisphere in most right-handed people (Falk, 2000). This fact confirms the assumption that musicians with perfect pitch show left hemisphere dominance.

Perani and colleagues (2010) found that this hemispheric asymmetry is even present at birth. They note that the right primary auditory cortex is involved in pitch analysis and integration.

It is interesting that if a musical score is just read, without playing or listening, the activated brain area is not the same. If words are read, a part of the Wernicke’s area on the left hemisphere is activated. During reading musical scores the activated area is on both hemispheres, a part of the visual area. Musicians do not read notes as isolated terms, rather in terms of their position relative to one another. (Falk, 2000)

In musicians who began their musical training before the age of seven, the anterior half of the midline area of the *corpus callosu*m is larger than in musicians who began their musical training later. The reason for that could be a stronger communication between the right and left frontal lobes. (Schlaug, Jäncke, Huang, Staiger, et al., 1995)

Further the central sulcus of both hemispheres is deeper in musicians who began to make music early. Musicians have a greater primary cortical area, especially the areas, which are relevant for sensory and motor functions for hands. They have a lesser activation in these areas than non-musicians, during finger tapping. (Falk, 2000)

Peretz (2002) reported that speech and music are two independent neural processes. She describes a study by Besson and colleagues (1998), where professional musicians from the opera in Marseille heard excerpts from operas. These excerpts ended either by semantically congruous words or incongruous words. These words, on the end of the excerpt of the opera, were either sung in or out of key. The electrophysiological response on the semantically incongruous word shows a negative waveform that peaked at 400ms, which is called N400. A late positive deflection was shown during a semantically congruous word sung out of key, was heard (P300). If a semantically incongruous word was sung out of the key, both waveforms were added together. This study is illustrated in Figure 2.

There are a lot of different processes in our brain, while we perceive music. In summary, different components of music as harmony, melody or rhythm activate different regions in our brain. There are differences between musicians and non-musicians, while they perceive or make music, and a difference between processing language and music.

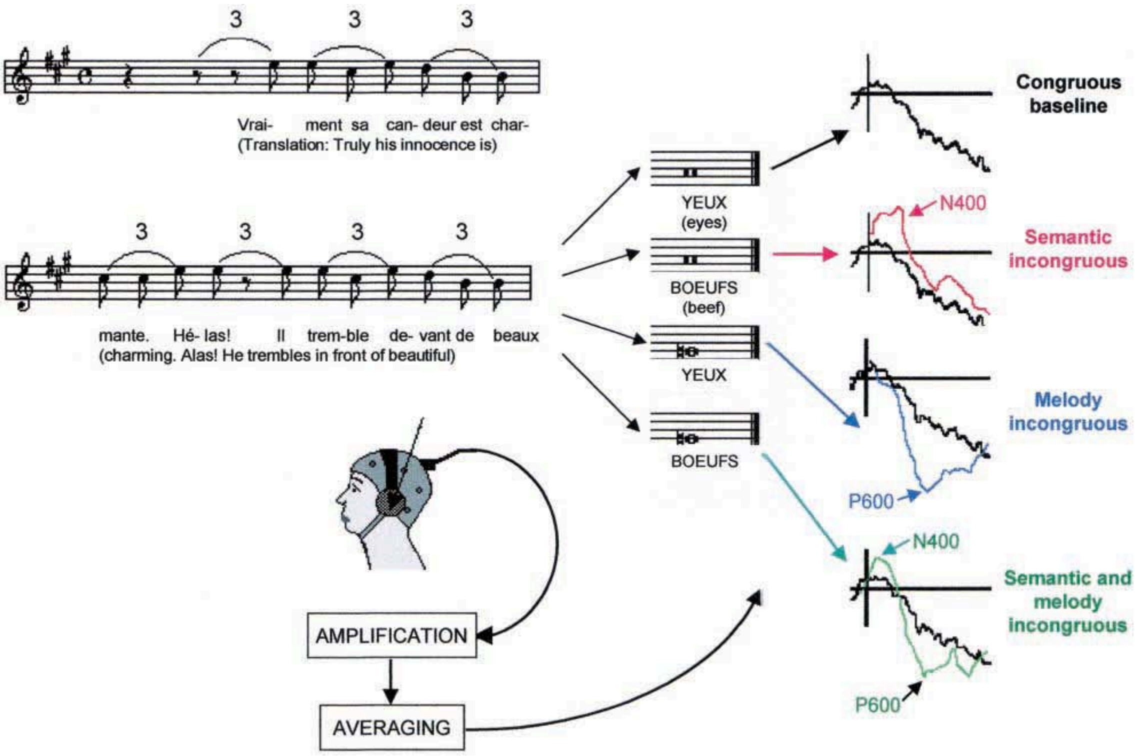

Figure 2: Example of the study of Besson and colleagues (1998) (Peretz, 2002)

1.2.3 Archaeological findings

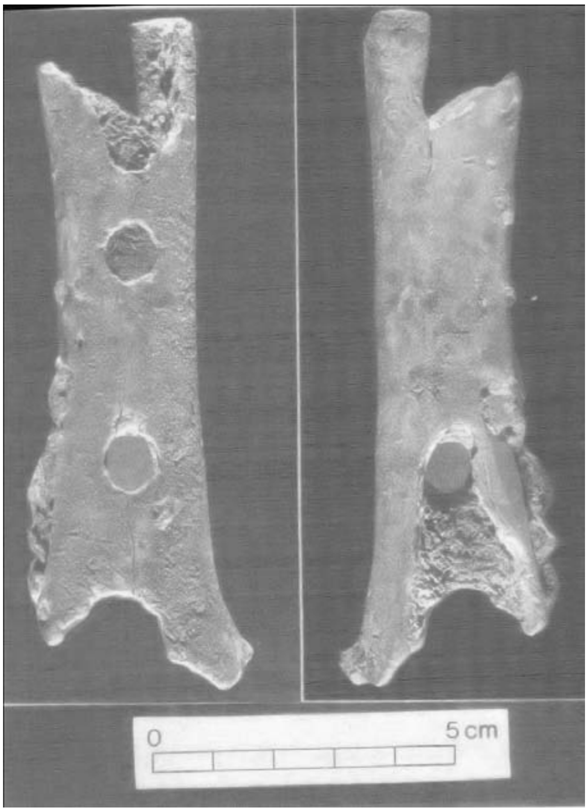

Figure 3: The bone flute from Divje Babe, Slovenia (Kunej & Turk, 2000)

Mithen (2005) does not believe that Neanderthals or other early humans could produce instruments. This needs a cognitively fluid mind, which is, in his view, first seen in the findings of Geissenklösterle, Germany, where a 36.000 year old bone flute was found. A bone flute that was found in Slovenia at the site of Divje Babe could be a Neanderthal one 10.000 years older (Kunej & Turk, 2000) than the one at Geissenklösterle. It is dated to the middle Paleolithic.

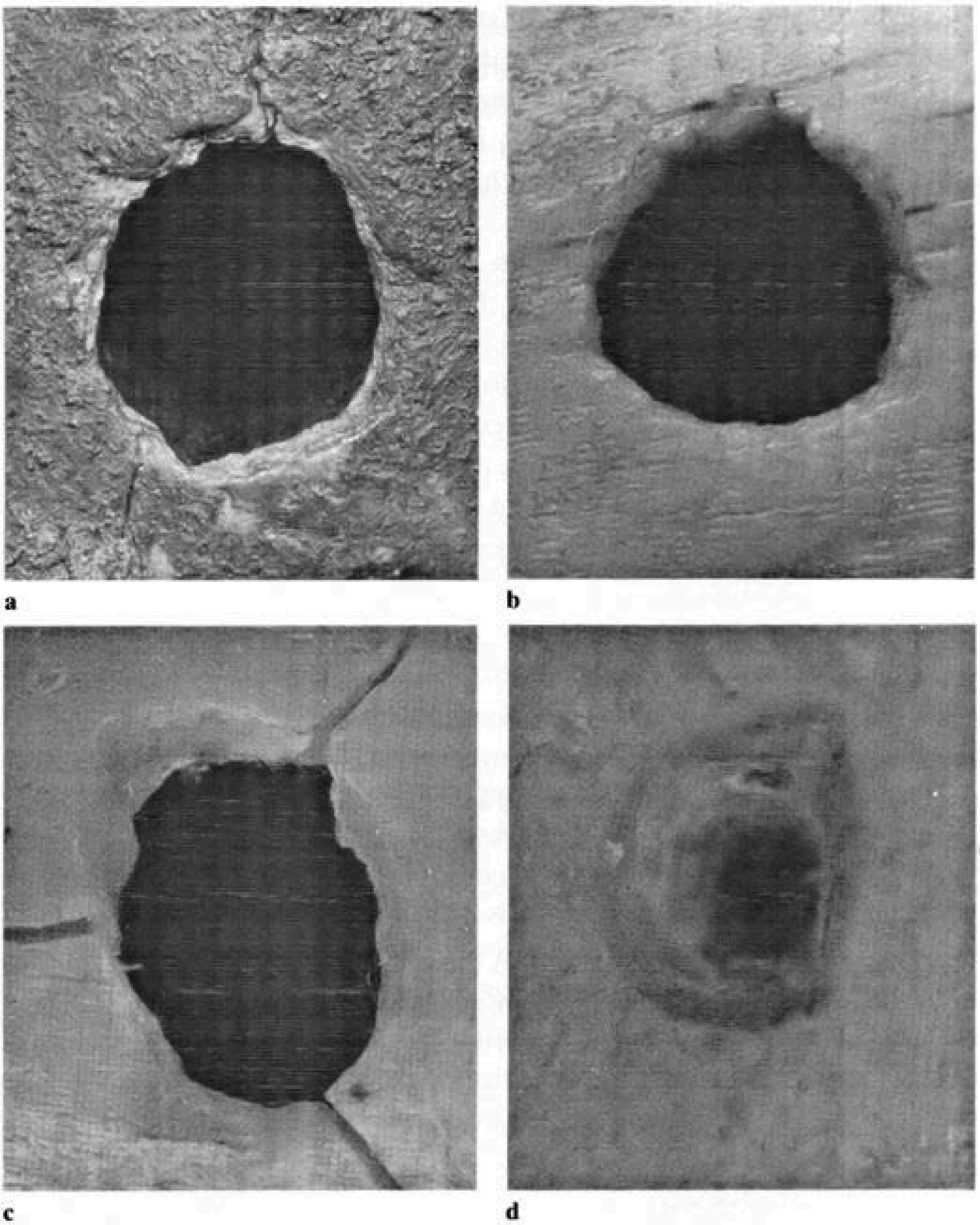

Figure 4: (a) one of the holes in the flute of Divje Babe, (b) experimentally with a stone tool chipped holes, (c) hole was made with a wolf's canine tooth, (d) hole was made with a hyena's tooth. All holes were made in a fresh femur of a young brown bear. (Kunej & Turk, 2000)

The flute of Divje Babe (Figure 3) is made of a left femur of a young cave bear. The bone has two complete holes on the posterior side, with a distance of 35mm between these two holes. Another possible hole is on the other side of the bone. The question arose for Kunej and Turk (2000), as to whether the holes are made by humans or rather by a carnivore, like a wolf. But they suggested that the possibility that these holes are made by carnivores are very low, because the complete holes on the bone show no signs of bite marks on the opposite side of the bone. The holes on the bone are too big for a wolf and their shape does not match a wolf's teeth. The shape does also not match with the molars of hyenas. The holes could only match the shape of canines of hyenas, bears or lions. But canines are not adapted for chewing and animals like bears or lions are not interested in bones. So Kunej and Turk (2000) completely exclude the opportunity that this holes are made by carnivores. This is all illustrated in Figure 4.

Kunej and Turk (2000) assume that the holes in the femur of the cave bear are made by humans. They found stone tools on the site of Divje Babe, which could be used to produce the holes on the bone, and evidence that stone tools are used to chip on the bone. The damage on the stone tools was similar to the damage on experimentally used stone tools, as illustrated in Figure 5.

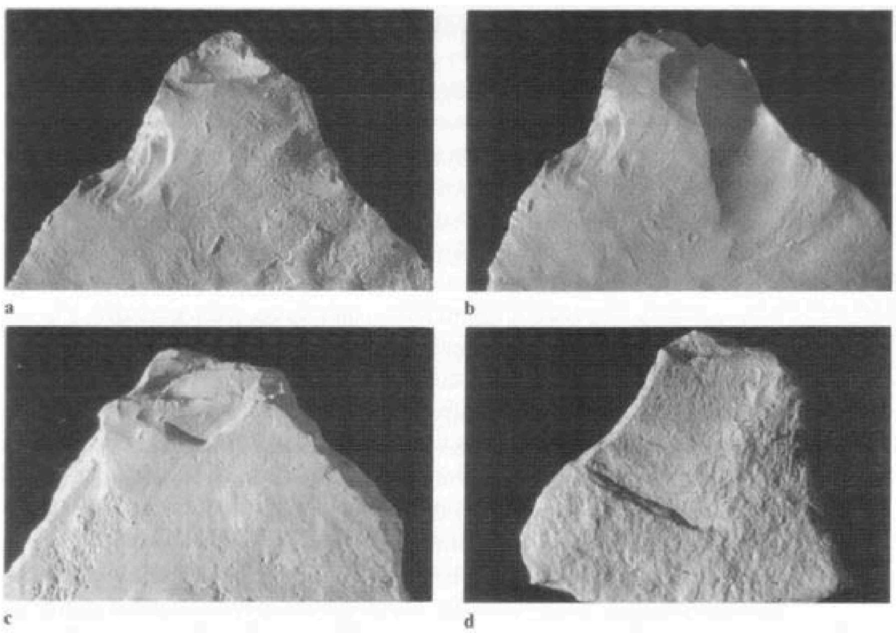

Figure 5: Damage on (a,b) the experimental used stone tools and (c,d) damage on the stone tools found in Divje Babe I site. (Kunej & Turk, 2000)

The distance between the third and the partial fourth hole is half the distance between the second and third hole (McDermott & Hauser, 2005). These distances correspond to the whole and half tones of a diatonic scale. Replicas of the flute were produced by Kunej and Turk (2000) and they recognized that they could produce tones of a diatonic scale. But also other tones could be produced, which depend on the position of the fingers and the way the flute was played.

Fitch (2006) argues that in this case the development of instrumental music has to have evolved 500.000 years ago. This means that the common ancestor of modern *Homo sapiens* and Neanderthal, the *Homo heidelbergensis* or *Homo antecessor*, had to have knowledge about instrumental music.

The earliest well preserved flutes were found in China, dated at 7.000 to 5.000 B.C. These flutes have up to eight holes and were produced from bones of cranes. (McDermott & Hauser, 2005)

Instruments were usually made of materials that do not fossilize and bone flutes are very uncommon in recent cultures. It is assumed that other instruments were used also, except bone flutes, which have not been preserved. (Fitch, 2006)

The first written piece of music was Sumerian, dated 1.400 B.C. The piece was encoded in the 1970s and even played 1974. The notes are related to a diatonic scale, but there is no evidence for tritone intervals and it sounds like a folk song or lullaby. (Kilmer et al., 1976)

McDermott and Hauser (2005) conclude that the Sumerian music piece sounded more familiar than exotic. So some features of Western music, like the importance of tonic notes have existed longer than Western music. This could be evidence for features of music that are universal through cultures and historical periods.

But it is difficult to study the beginnings of instrumental music, because it is possible that the musical instruments of our ancestors were made of materials that do not fossilize and are not preserved today. It is also impossible to find any evidence that our ancestors sang together or alone. These are things which did not fossilize, so they cannot be studied.

1.2.4 Discussing how music has evolved

The first anatomical prerequisites for singing and speaking are seen in *Homo ergaster*, who lived about 1.75 million years ago. *Homo ergaster* was the first who showed a *basicranial flexion*, which means that the skull base was curved. Additionally the first sign was present that the larynx had moved down, leads to an increase of the resonance cavity. (Laitman, et al., 1979)

Homo heidelbergensis, who lived 400.000 to 300.000 years ago, shows a fully curved skull base. So it is possible that *Homo heidelbergensis* has a nearly full repertoire of vowel sounds, like a modern *Homo sapiens*. (Laitman, 1984)

In contrast, the Neanderthal had a much longer and flatter skull base. This may has reduced his speech as well as singing production. (Laitman, et al., 1979)

Also the size of *the hypoglossal canal* gives a hint about the ability to speak. The *hypoglossal canal* has the same size in *Australopithecus afarensis*, *Homo habilis*, *chimpanzee* and *gorilla*. *Homo heidelbergensis*, *Homo neanderthalensis*, and early *Homo sapiens* had a channel that is nearly as large as in modern *Homo sapiens*. Through this channel runs the *hypoglossal nerve*, which is the twelfth cranial nerve that innervates among others the muscles of the tongue. It can be assumed that the movement of the tongue we see today has developed 300.000 years ago *in Homo heidelbergensis*. (Morley, 2002)

The co-evolution of these aspects and still many others make it clear that the first step for both language and music were shown in *Homo ergaster*, 1.75 million years ago. A full development did not appear until *Homo heidlebergensis*, about 400.000 years ago.

The first evidence about development in Broca's area was shown in *Homo habilis* (Falk, 1992). So probably *Homo habilis* had the ability to produce speech, but this is affected by the fact that the *hypoglossal canal* was smaller in *Homo habilis* than in *Homo sapiens*. *Homo habilis* did not have the same ability to move his tongue as *Homo sapiens*. This suggests, apart from the development in Broca's area, that he was not able to produce speech.

These data need to be supplemented by archaeological findings. The oldest find that could possibly be an instrument, a bone flute, is about 50.000 years old and is connected to the Neanderthal culture. However, one cannot rule out absolutely that the holes in the cave bear femur are caused by carnivores. There were no certain indications found that the holes are made by humans. (Kunej & Turk, 2000)

If we call this a musical instrument, than the origin of instrumental music, according to Fitch (2006) must be at least 500.000 years old, because the common ancestor of Neanderthal anatomically modern human have already have the knowledge for music. Therefore this was *Homo heidelbergensis*. Further Fitch (2006) mentioned that the oldest certain find of a musical instrument, is a pair of bone flutes. These are found in Geissenklösterle, Germany. These flutes are about 36.000 years old and so the minimum age of instrumental music has to be 36.000 years.

When one considers these assumptions in more detail, then music is evolved between 1.75 million years and 40.000 years ago. This is a very long period of time, a great degree of uncertainty. Many issues have not been solved yet.

2 Evolutionary background

The next step is to explore which fundamental evolutionary process caused the evolution of music. The first question arising in this section is why human music has evolved. Are there similarities between human music and communication signals in animals that are propagated as songs? Animals like birds or gibbons do something similar to human singing. Scientists try to explain the development of music in humans by answering questions about the proximate mechanisms of singing in animals like birds and gibbons.

Another question is of the function of human music to discover the ultimate cause of music in humans. In this context, it is very interesting to explore the importance of music in mother-infant communication.

Afterwards I will explore different evolutionary processes that probably have caused the evolution of music. Therefore I will show how scientists argue to explain this ultimate cause of the evolution of music. Is music an adaptation, and for which adaptive function? Adaptations are inherited and reliable developed characteristics, which are evolved by natural selection, because they helped to solve survival and reproductive problems. If this is the case, which selection process caused this adaptation? Is it possible that music is caused by the process of sexual selection? In sexual selection, males are chosen by females of the same species on the basis of a specific feature giving them an advantage over other males in competition for the females, concerning reproduction (Darwin, 1871).

Another possibility is the process of group selection. This process, introduced by Wynne-Edwards (1962), speculates that altruistic individuals behave in a way which benefits the group. Such a group has a better chance for survival than a group without altruistic behavior. This behavior has costs for the individual, but benefits the group.

The last process is kin selection. This means that individuals help their relatives. In this case they encourage the replication of their own genes, because for example siblings share fifty percent of their genes. The higher the degree of kinship, the higher the altruistic behavior. (Hamilton, 1963)

If music is not an adaptation it could still have evolved as a byproduct. A byproduct is not an adaptation but is linked and carried with an adaptation.

My last question is, whether music is an analogous or homologous trait. Analogous traits are by definition, similar traits in two species that arose twice. In contrast homologous traits are similarities between two species because of descent from a common ancestor.

To answer these questions I will contrast different arguments of various scientists.

2.1 Why has music evolved?

The first consideration to answer is the question of the origin of music – which function does music fulfill? The first point to consider is what function music or song has in animals, like songbirds or our closer relatives, primates. Further it is important to look at the functions of human music. For example, how important is music or song in mother-infant communication, which could be the beginning of human music?

These questions will be explored in the next three sections.

2.1.1 "Singing animals"

Fitch (2006) defined songs in animals and humans as complex learned vocalizations. The only known animals able to learn vocalizations are birds and cetaceans (Marler, 2000). Cetaceans are marine mammals, for example whales and dolphins. That birdsong is learned differentiates it from other vocalizations present in birds.

Chickens raised in acoustic isolation still sound like chickens. But if songbirds are raised in acoustic isolation, they sing abnormally simple songs, called isolated songs. This shows that vocal learning is present in songbirds. This is surprising, because monkey and apes are not able to learn vocalizations. (Whaling, 2000)

Birds sing because they are raised in an environment full of songs, which they learn. Furthermore they sing, in an adaptive context, because their ancestors won the competition in reproduction against their rivals that did not sing. This could have happened because the singing individuals attracted more and better mates and also defended their territories better. (Fitch, 2006)

Birds do not produce sounds in the way we do. Humans have a larynx, which is attached high in the throat. Birds have also a larynx, which is not used for sound production, but also a syrinx, which sits much lower in the throat. It is at the place where the ducts – bronchii – from the lungs, convene and build the trachea. Sound production is the only function of the syrinx and is very different between bird species. There are two separated membranes, each one having its own set of muscles. These make it possible for birds to produce two independent sounds at the same time. A correlation is known between the complexity of the syrinx and the complexity of singing. Neural factors have to play an important role in song complexity as well. (Fitch, 2006; Slater, 2000)

Songbirds belong to the order of *Passeriformes* and the suborder of *Oscines*, which are nearly half of the known bird species. The ability to learn vocalization has possibly evolved three times in birds: in songbirds, parrots and hummingbirds (Doupe & Kuhl, 1999). The syrinx of *Passeriformes* has five or more pairs of muscles, in contrast to other bird groups that only have three or fewer (Slater, 2000).

The function of this behavior is to attract and stimulate females and to defend their territory against other males. Males with longer song repertoires are preferred by females – they have greater reproductive success. (Slater, 2000)

It was long believed that only male birds sing, but this seems to be a historical accident. In temperate climate regions, singing males are common, but in the tropic regions duetting of males and females, and also solo performances of females are common. This accident happened because if females and males looked identical, the singing individual was thought to have been the male one. Later with laparoscopic sexing and tagging, it was realized that female song is very common. It is also interesting that the females of a species that normally does not sing, can be stimulated to sing with male hormones. So it seems that the neural mechanisms for song are present in females, even though not expressed. (Fitch, 2006)

In primates singing is connected to monogamy. Singing in primates only appear in two groups of prosimians (tarsiers and indris), one New World monkey, (titi monkeys), and one ape (the gibbon). The commonality between these four groups is that they are monogamous. The monogamous pairs of one female and one male live in and defend a territory, and also defend exclusive sexual access to each other. In gibbons it seems as if singing strengthens the pair bond and helps defend their territory. Singing together is only done by individuals who have a long-term, monogamous relationship. These individuals are dependent upon cooperation with each other for their own survival and reproductive success. (Falk, 2009; Mithen, 2005)

A lot of similarities are shared between gibbon songs and the calls of great apes, which lead to the conclusion that singing and calling in all apes evolved from a common ancestor. The human voice is the most ancestral instrument used in music and so the loud calls of our ancestors are the beginning of human singing and music. Additionally apes cannot keep time and are not able to keep rhythm. So it is possible that rhythm evolved more recently than loud calls or songs. The ability to learn phrases and to improvise evolved more recently. A main feature of gelada and gibbon communication systems is that they use rhythm and melody and synchronize their calls. (Falk, 2009; Geissmann, 2000)

Geissmann (2000) describes gibbon communication as loud and long song bouts. The average duration of these bouts are ten to thirty minutes, which varies with species and context. These songs occur mainly in the morning, which also varies with species. Gibbons also are specialized for duetting, except the species of *Hylobates klossii* and *Hylobates moloch*. These duets are mainly sung by mated pairs. The pairs mix up their repertoire in exactly timed vocal interactions to produce these duets. Gibbon songs are not learned, as shown by studies on vocal repertoire in various hybrid gibbons. (Geissmann, 2000)

According to Geissmann (2000) duetting has to be learned at the beginning of each pair bond. This would reduce the possibility of leaving the partner, because of the investment learning the duet would require for each new partner. Further Geissmann (2000) assumed that three conditions have to prevail. The duetting have to benefit the possibility to copulation after pair formation. It is also important that the duets are pair-specific and this have to be a mate-specific duetting relationship of only one mate. In wild *Hylobates agilis*, *Hylobates lar*, *Hylobates klossii and Hylobates syndactylus* subadult males sing more often for longer durations and also earlier in the morning than mated males.

Fitch (2006) insist that there are no singing primates except humans, because their communication, which some scientists call singing, is not a learned vocalization. So primates, except humans, do not sing.

2.1.2 Function of human music

Music is used to accompany dance. It is also very important to events like weddings or funerals. Music is important in ritual and contexts that are associated with supernatural things, like gods. It is also very important to change the attitude of individuals at social gatherings.

Today music is still important to show the relationship to a special group, for example political, religious or age-sorted which are often defined by a special style of music. These special styles are for example national hymns, military music, battle songs of fans or cheerleaders, or musical preferences of young people, who demonstrate their membership in special youth groups.

Singing and dancing are very important during religious and social ceremonies. There members of a community come together at a central, for them important, place together with musicians and their instruments, priests, maybe a altar and religious symbols. Religious ceremonies produce a collective mental state of extreme emotional intensity.

Music often manipulates our emotions. If we hear a spoken statement then we are able to have an idea about the thoughts of the speaker. It is the same with music; if we hear a song then we feel emotions in ourselves, because music manipulates our emotions. Mithen (2005), in fact, believes that the music, which was played with the flutes, found in Geissenklösterle, Germany, had a religious function.

An adaptive function of music is regulating and influencing our emotions. But this is not unique to music or humans. Additionally humans and animals are able to encode emotional information from vocalizations (Hauser & McDermott, 2003). They also have perceptual systems that make it possible to react to those signals. A cross-cultural study of Balkwill and Thompson (1999) tries to figure out if Westerners feel the same emotions as native Indians, while they hear North Indian ragas. Their result was that Westerns and native Indians often had the same emotions during hearing this kind of music. This suggests that some functions of emotions in music are probably cross-cultural, which may be evidence of innate mechanism during music perception. Hauser and McDermott (2003) thought that it would be interesting if we share this mechanism with our nonhuman ancestors.

Modern language does not use the complete vocal tract. It is possible to speak in a complete monotone, without any loss of meaning. In contrast, singing does use the complete vocal tract. The vocal tract originally was designed for singing and not for speaking. Singing behavior evolved in animals to declare territorial information, for courtship display and pair- or group-bonding. These are requirements that are much older than language. Perhaps singing evolved for the same reason in animals and humans and that language now take possession of the mechanisms which are originally evolved for singing. (Vaneechoutte & Skoyles, 1998)

2.1.3 “Motherese”

It seems that lullabies are used in every culture to soothe infants and lull them to sleep. They are distinctive from other songs, and babies prefer to listen to lullabies over adult songs, especially if they are sung by women. Their rhythm, regularity and simple structure help to shape and control the emotions of infants. Also, adults who listen to lullabies in a foreign language are able to distinguish these songs from equally slow non-lullabies. (Falk, 2009)

“Motherese” is a special singsong way adults talk to infants, also called “musical speech”, “baby talk” or “infant-directed speech” (IDS). Infants prefer this talk over the way adults speak to other adults. This preference increases during the first several months of their life. “Motherese” is used by adults until the infants are about three years old and most intensively used with three-to-five-month-old infants. (Falk, 2009)

“Motherese” is characterized by stressing certain syllables within words, and certain words within sentences. It is slower and more repetitious than speech directed to other adults. Other characteristics are a higher overall pitch, simpler vocabulary and the use of special words like “doggie”. The sentences are often short and straightforward and contain words that describe the child’s immediate environment. It also contains a high proportion of questions and usually the present tense is used. The complexity of “motherese” increases with the age of the infant and it is automatically adapted to the comprehension level of the infant. Additionally “motherese” is melodic and also expresses emotions, as well as lullabies and play songs.

Infant-directed speech is characterized by a higher overall pitch, a wider range of pitch, longer “hyperarticulated” vowels and pauses, shorter phrases and greater repetition (Mithen, 2005). Infants prefer listening to infant-directed speech, and they are more responsive to intonation of voice than to facial expression. Additionally infants until they are four months old prefer music with consonant intervals such as a major third to music with dissonant intervals such as a minor second (Pinker, 1997). Mother’s vocalizations and movements have to have a special tempo and variability to get and keep the attention of a three-month-old child. (Beebe et al., 1982)

Trehub (2001) reported that six-month-old infants who view recorded performance of their mothers singing to their infants show a higher response to their mother’s singing than to their speaking. So singing maybe serve as a care-giving tool. Music perception skills of prelinguistic infants are similar to adults who listen to music over years (Trehub, 2003).

To Falk (2009), “motherese” is a sort of “Protolanguage” and evolved before the first language. There is association between exposure to baby talk and acquisition of language in modern infants, raising the possibility that language may have evolved from a prehistoric form of “motherese”. Perhaps music and language stem from ancient communications that maintained and reinforced pair-bonds between mothers and infants. Premature infants develop sucking abilities and gain more weight if they hear a woman sing lullabies, and bouncing babies in time to music help them to develop musical sensitivity.

Dissanayake (2000) agrees: “motherese” is possibly the fundamental source of music-making among adults and in every culture. These musical aspects of infant-directed speech may have evolved as a direct response to the increasing helplessness of infants in early hominids. The musical character of mother-infant interactions provides benefits to both parties. Musical sound and movement express and induce emotional states and lead to consonance between the emotions of parents and infant. This could be coevolution of rhythmic, temporally patterned, and jointly maintained communicative interactions, which produced a positive effect for both.

Mothers who were gatherers would have to put down their babies, when they collect fruits. But the mother would still have eye contact, gestures, expression and utterances to reassure the infant. Infant-directed speech and their emotionally manipulative prosodic characteristics would have been a “disembodied extension of the mother’s cradling arms”. (Falk, 2009)

A crying baby possibly created the same unwell feeling in early human mothers that mothers feel today when their babies cry. Today, too, mothers who are too busy to pick their babies up comfort them with utterances and gestures of infant-directed speech. This is Falk’s (2009) theory of the evolution of baby slings.

There is no reason that Neanderthal parents would not have used music-like vocalizations, body language, gestures and dance-like movements to communicate with their infants, similar as modern humans today. (Mithen, 2005)

These rhythmic parent-infant interactions, similar to song, could be a common ancestor to musical behaviors and modern language (Morley, 2002). Additionally Dissanayake (2000) supposes that the development of bipedal locomotion and a larger brain in humans affected a lot of factors, like gestation length and a higher investment in their infants, because the narrower birth passage leads to continued brain development after birth. Infants born premature need longer and better maternal care. Dissanayake (2000) suggests that this was implemented by higher mother-infant communication. Modern infants are able to react to different frequencies, intensity, duration, and temporal or spatial patterning of sound, which represent the emotional aspect of the human voice. Two-month-old infants are even able to recognize rhythmic facial and body movements.

This has eight benefits.

(1) The mother directs and modulates the infant's attention and arousal.

(2) She also regulates and supports the emotional state of the infant.

(3) Mothers offer acquaintance with features of language. These are the same features by which adults get information about other adults, like sex, age, and so on.

(4) She gives "exposure to the prototypical and meaningful sounds and patterns of spoken language".

(5) Infants develop cognitive functions to recognize "agency, object, goal, and instrumentality". This helps the infant to get intellectual and social competence.

(6) They support the development of neural structures in infants, which are important for socio-emotional functions.

(7) They learn the standards for a culture and its correct behavior.

(8) They get physiological and emotional features to strengthen the pair-bond between mother and infant.

All these involve similarities between music and "motherese": both use sequential structural features, which have some emotional meanings; both use cross-modal neural processing and "kinesic and visual as well as vocal channels"; for both, physical movement is important, and both are also used for social regulation and emotional bonding. (Dissanayake, 2000)

Additionally Fitch (2005) noted that the "childcare hypothesis" can be seen as an adaptive function of music. So music possibly evolved from mother-infant communication.

2.2 Adaptation

Adaptations are inherited and reliable developed characteristics that evolved by natural selection because they helped to solve survival and reproductive problems. McDermott and Hauser (2005) assumed that some aspects of music could be byproducts, while others are specific adaptations. Already Darwin (1871) suggested that human music was a biological adaptation, caused by sexual selection, that functions mainly as a courtship display to attract a sexual partner. Music is a multifunctional adaptation and uses a “large diversity of functional roles in all cultures” (Brown, et al., 2000).

To the contrary, Pinker (1997) argues that musical expertise varies across people, cultures and history, whereas language does not. All healthy children spontaneously begin to speak and understand complex language. Complexity of spoken dialects varies but little across cultures and history. In contrast to language, which everyone can speak and understand, many people cannot carry a tune and fewer are able to play an instrument. The people who *are* able to play an instrument, need a lot of training and extensive practice. Also, according to Pinker (1997), “music communicates nothing but formless emotion”. He concludes that this suggests that music is different from language, that it is only a technology and not an adaptation.

Mithen (2005) noted that this converse might be true, because music could be a mental adaptation primarily generated for music that later became used for language.

2.2.1 Sexual selection

Darwin (1871) noted that the primary benefits of music are reproductive ones, which are explained best through sexual selection. These are the same processes by which bird song has emerged. This leads to the conclusion that music has to be a biological adaptation that functions mostly as courtship display to attract a partner. Music is present in all cultures and musical abilities spontaneously develop in children, leading to the conclusion that music tones and rhythm were used by our half human ancestors, during the season of courtship.

Miller (2000) mentioned that nobody ever found any survival benefits of music for the individual. If evolution did use the theory of the survival of the fittest, music could not be explained. Miller (2000) refers to the musician Jimi Hendrix, who died at the age of 27 on an overdose of drugs. His musical qualities led him to recording three studio albums and playing hundreds of concerts, but didn't give him any survival benefits. Jimi Hendrix possibly had liaisons with hundreds of women, and three children. But without contraception he would have had lots more. So music gave him a reproductive benefit. In contrast Mithen (2005) assumed that his sexual attraction arose from a combination of good looks, style and being an antiestablishment figure and not only from his music.

Another point on Miller's (2000) view is that fitness means a survival or reproductive profit, which exceeds its biological costs. Music would have high costs for our ancestors, because they would be noisy through musical production and that would attract predators and competitors. Our ancestors also needed energetic bodies for dancing, because they had to practice and perform for hours. Additionally it possibly kept their sleeping babies from getting rest. If music is a complex biological adaptation, it has to emerge through natural or sexual selection. According to Miller (2000) there are no other options to explain a complex adaptation in nature.

In contrast Fitch (2006) mentioned that mating success in Western, post-birth control cultures is not reproductive success. So it would be important to have more data from traditional cultures.

Animal signal systems manipulate the behavior of a receiver to benefit the one that produced the signal. Music is a signal, which is sent within one species – humans. Hauser (1996) split up these signals in different categories. There are signals between competitors, warning calls between kin, contact calls between group members, dominance and submission calls, and courtship signals. Courtship signals are the more complex, more varied, more continuous, more energetically expensive, and more interesting to a human observer. Based on the function of music as a signal within a species, music is a sexually selected courtship display, such as all other complex sounds in animals. In summary, Miller (2000) stated that music has costs, but no survival benefits, though reproductive benefits. These reproductive benefits caused the evolution of music, because the main function of music is sexual courtship.

Females choose males who are good hunters, have energetic bodies and are the fittest. These qualities are, for example, observed during hunting. While our male ancestors were hunting, the female ones stayed at home with the children or collected food. So they cannot observe the males during hunting, and cannot discover who the best hunter is. Most of the courtship display occurs in the evening, around the fire, if the whole group stays together. This possibly leads to the evolution of dancing in the group, where everyone uses the same rhythm. In most tribal and folk dancing high stepping, stamping and jumping are involved. Therefore the largest muscles, the ones that need the most energy in the human body, are used. So dancing probably is a good test for fitness. This gave females a possibility to check out which male is the fittest, best hunter with the most energetic body, without observing them during hunting. This behavior possibly also minimizes the costs for searching for a partner in females, because all males are in the same place, and so females are able to observe every male at the same moment, and compare them. (Miller, 2000)

Assuming that in societies of australopithecines and early Homo male-male competition and female choice had existed, sexually selected vocal displays were present. According to Mithen (2005) it is possible that the semi-bipedal australopithecines and the earliest Homo had achieved its grade by an improved range of vocalizations, which are also found in African apes today. These vocalizations improved further in the fully bipedal *Homo ergaster*.

There is evidence for male display, even though not for male singing or dancing. Perhaps production of stone tools, like hand-axes, was done for social display. Early humans could generate attractive melody and rhythmic sound, while they produce stone tools by chipping at the stone. (Mithen, 2005)

In contrast Fitch (2006) noted that music perception and singing evolve very early in human babies, but sexually selected traits usually do not develop until sexual maturity. And there is no evidence for sexual dimorphism in music (Huron, 2001). Both sexes have a similar ability to produce and listen to music. How can you have sexual selection without sexual dimorphism? Likewise, Fitch

(2006), there is no sexual dimorphism for instrumental music. Women instrumental players are as good as men. The claim of sexual selection surely conflicts with the fact of singing mother-infant interactions and with Falk's (2009) argument against Miller (2000) that sexual selection is not possible, because music-making had important benefits for our ancestor and relatives in communicating emotions, intentions and information.

"Why are there so many love songs on the radio?". In a mating process there should be only little variation. But if communication is manipulation, the signal should be the one which is most effective. According to Werner and Todd (1997) sexual selection should lead to variety in male songs and female preferences for them. It could be possible that females not only choose songs which are based on their preferences, but these songs have to surprise the females. If females are bored by an old song, males have to surprise them with a new song to ensure their mating success. If music is caused by sexual selection, it has to be a signal which benefits the survival of an individual or his relatives.

2.2.2 Group selection

By the time of *Homo habilis* and *Homo rudolfensis* the group size had grown large. In these large groups, grooming was no longer possible. It was an inefficient way to express one's social commitment to other members of the group. So much time would be spent for grooming, that they would have had no time for other activities such as finding food. So language may have evolved as a form of "vocal grooming", which could shared with more than one individual at the same time, and is more efficient. One example of vocal grooming can be observed among gelada monkeys; their use of rhythm and melody. Singing together allows social bonding, which may be a form of grooming. (Aiello & Dunbar, 1993)

Robin Dunbar notes that music making in a group lead to endorphin surges within the brains of the participants, so that they feel happy (Mithen, 2005). The endorphin surges are greater if they make music together with other people. During group music-making, also, the hormone oxytocine is released in the basal forebrain (Freeman, 2000). Freeman (2000) describes music as the "biotechnology of group formation".

Social bonding seems as a common feature for speech and music. Dunbar (1997) reported that 70 percent of all conversation is used only for social exchange of information. This was also found for music in today hunter-gatherer societies and traditional cultures. So music could be a kind of “proto-language”, like Vaneechoutte and Skoyle (1998) and Mithen (2005) assume.

Aiello and Dunbar (1993) suggested that social use was probably the primary selective pressure for the development of complex vocalization and even full language. This is evidence for music based in the same emotional and social fundamentals as language. According to Fitch (2006) “proto-music” may have special functions, like courtship-display or defending territories, which today only exist as a relict and whose functionality was replaced by language.

Making music together in a group involves synchronizing vocalizations and movements. But modern-day chimpanzees for example are not able to synchronize their vocalizations. (Mithen, 2005)

In primate groups, females leave the group where they are born, and join another group for mating and rearing their young. So males of a group are interested in attracting these females. A coordinated, synchronous rhythm and melodic group behavior may have evolved from synchronous choruses (Merker, 1999) used to attract females from other territories. The prerequisite for this behavior was that populations from the lower and middle Palaeolithic were exogamously organized. This means that females left the group where they are born in and join another group to settle down and raise their young. So males may make distance-calls to attract females from other groups. If more males synchronize their calls, they increase the area reached by the calls. After the group attracted a female, it is important for some single male to win the female for himself. So every individual male also had to have an individual call, which differed a little bit from the group call. Merker (1999) believes that this is the root of human music.

But is there any similar behavior in any other primate species today? Morley (2002) and Mithen (2005) note that this behavior is only found in insects. Also, synchronous callings would attract predators, not only mating partners.

According to the theory of the “selfish gene” (Dawkins, 2006), reproductively successful individuals should look after their own interest in reproduction. We expect that if we help other people, that these people in turn help us. So perhaps music is a way to demonstrate the willingness to cooperate with others in situations such as food sharing or hunting. “Tit for tat”: I help you, you help me. Music is cooperation without risk, because if one member does not cooperate, as by not joining the song or dance, the others have nothing to lose. So there are only few costs or benefits associated with music making in a group – free-riders cannot exploit the situation. (Mithen, 2005)

Death was probably an intensely emotional event for our ancestors. They probably needed song and dance to create a shared emotional state. This should have helped them to consolidate and confirm social bonds and to promise future cooperation.

For all proto-humans the social bond of the group was more important than the individual. So music has to be essential for them. For modern humans, if they live in poverty, they make music, because this enables social bonding and make it easier to help each other. Mithen (2005) believe that Neanderthals did it in the same way. This implies that communal singing and dancing were very important among the non-linguistic, non-symbolic, ancestral populations in Europe.

The people who live today in the Western world eat more and have more sex than biologically required, and do it today more for pure pleasure or entertainment. But their social bonding role still exists. According to Mithen (2005) music is the same. It still has some of its adaptive functions of group-bonding, but today we also enjoy making music, just for pure pleasure.

Miller (2000) noted that those who claim group selection for music ignore Darwin’s (1871) insight that the benefits for music are reproductive ones best explained by the process of sexual selection: the same process that forced the development of singing in birds. The explanation that music evolved due to group selection cannot be the case, because this “has never been needed to explain any other trait in any mammalian species” (Williams, 1966). According to Miller (2000), birds charm females, even while they are in a larger group of males. This is efficient for females, because they can wander around and search for the best male in the group. This minimizes search costs for females and pushes males to compete against each other in larger groups. This behavior is a selfish one, Miller (2000) argues, without any tendency to group selection. According to him, the fact that music is always made in groups is always interpreted as some sort of group function, but this need not be the case. The theory of group selection is favored by some scientists because it is a “kinder, gentler, more cooperative, more humane form of evolution than individual selection”. But this theory failed to think about free-riders, the individuals who do not pay the costs to get the benefits. If a group dances the whole night to get for example better bonding, and one free-rider, who does not participate at the dance saves time and energy, but gets the benefits. This sort of free-rider would spread through the population. After a few generations, there would be more free-riders than dancers and music would die out.

But Miller (2000) also claimed that it could be possible that if music has benefits for the individual, like courtship benefits under sexual selection, then it is possible for group selection to increase the individual benefits, by group benefits. So music would not be “altruistic”, with individual costs and group benefits. This means if none of the dancers of the group would mate with a free-rider then the free-riders are not able to spread the group. Additionally he mentioned that this model is studied very poorly (Boyd & Richerson, 1990). For Miller this interaction between group selection and sexual selection is the only way to explain music: it has to be due to group selection.

Music may have evolved because in our ancestors, groups of musicians outcompeted groups of non-musicians (Brown, 2000). These are factors of group-level cooperation and coordination. Multilevel selection models are responsible for the development of music. These models may involve group selection and cultural group selection (Boyd & Richerson, 1990).

Another way to explain music through some group-bonding mechanism that Miller (2000) mentioned is a collective access to the supernatural for a group. On this point he refers to Bruno Nettl (1983), who argues that this supernatural phenomenon, like singing in a church, could have some bonding function. Miller

(2000) insists that accessing the supernatural can only be an adaptive function of a biological trait like music. There also have to be some benefit from accessing the supernatural. There would not be any selective pressure on individuals, who think that they gain any supernatural power from a god-like creature. For selection they must get some supernatural power.

After all, as Geissmann (2000) noted, a important function of human music, which was probably also present in early hominids, is to display and reinforce the unity of a social group. This function is still present today in, for example, national hymns or military songs.

Another hint that music evolved under the pressure of group selection is given by Huron (2001), who compared two mental disorders – Williams syndrome and Asperger Autism. People with Williams syndrome show high verbal abilities, high sociability and high musicality. In contrast, people with Asperger Autism have very limited social skills. These people also have reduced mental function and an emotional deficit. They also show low musicality. Huron (2001) concluded that this fact probably shows a connection between sociability and musicality, because people with Williams syndrome show high sociability and high musicality, but in contrast people with Asperger syndrome show low sociability and low musicality. According to him, this suggests a link between sociability and musicality. So he makes the assumption that music has a “group-oriented evolutionary account”. On the whole, a current understanding of prehistory is more consistent with group selection than with kin selection.

2.2.3 Kin selection

Fitch (2006) assumes that music preserves group-bonding. Verbal exchange in humans acts as a sort of “vocal grooming”, replacing the physical grooming, the standard practice in primates. During the coordinated singing of a group, endorphins are released. (Dunbar, 1993, 1996)

But it is easy to mistake kin selection for group selection. Groups are often made up of closely related kin. Individuals are nice to others who share their genes, so they are rather egoistic. (Fitch, 2006)

Miller (2000) counters that kin selection seems implausible, because no other species with cooperation between kin requires any special bonding ritual. But music and dance seem not to play that important role in family groups that it plays when non-kin come together.

2.3 Byproduct

A Byproduct is not an adaptation but a feature connected to and carried with an adaptation.

The starkest view of this possibility is Pinker's (Pinker, 1997) who noted that "music is auditory cheesecake, an exquisite confection" and only a byproduct of selection in other cognitive domains, for example, language, emotional calls or habitat selection.

Indeed music borrows some of its mental machinery from language, especially from prosody. Metrical structures – strong and weak beats, the intonation contour of rising and falling pitch, and the hierarchical grouping of phrases within phrases – all seem to be similar in language and music. Music, like language, seems to carry a complex message. As mentioned in chapter 1.1, according to Pinker (1997) music is called "heightened speech" and it is possible that it grades into speech.

The second cognitive domain borrowed by music is "auditory scene analysis". The ear receives a lot of different frequencies and must segregate streams of sound from different sources, for example the soloists in an orchestra, a voice in a noisy room or an animal call in a chirpy forest. The brain identifies these different streams of sound by paying attention to different harmonic relations. According to Pinker (1997) "building a melody is like slicing a complex harmonic sound into its overtones and laying them end to end in a particular order".

The next cognitive domain is the "emotional calls". If people try to describe passages of music in words, they use words like whimpering, whining, crying, weeping, moaning, growling, cooing, laughing, yelping, baying, cheering and so on. These are emotional calls. Maybe melodies induce strong emotions, because they are similar to our species' emotional calls. (Pinker, 1997)

Another cognitive domain borrowed by music is “habitat selection”. Pinker (1997) assumed that we pay attention to features of the visual world, which signal safe, unsafe or changing habitats and possibly we also pay attention to these features in the auditory world. For example, thunder, wind, rushing water, birdsong or growls all have emotional effects. An example using these features in music is probably found in cinematic soundtracks. These do not have real rhythm, melody, or grouping but are able to lead the moviegoer from feeling to feeling.

The next to last is “motor control”. According to Pinker (1997) rhythm is the universal component of music. People dance, nod, shake, stride and clap to music, all hinting that music taps into the system of motor control. Actions like running or walking have an optimal rhythm. We enjoy dancing from being able to stick to it. So music and dance could be a concentrated dose of that stimulus.

The last one Pinker (1997) mentioned is “something else”. It could be possibly a resonance in the brain between neurons firing in synchrony with a soundwave or an unused counterpart in the right hemisphere of the speech areas in the left or only some kind of spandrel that came along as an accident of the way that auditory, emotional, language, and motor circuits are packed together in the brain.

For Pinker (1997) music is useless and it gives no benefits to the individual like a long life, grandchildren, or accurate perception of the world. According to him, music could disappear from our species and nothing would change. Further music is only a “pure pleasure technology” and so complete different from language that it could not be an adaptation.

Dougherty (2006) mentioned that music is rather a byproduct, an “exaptation”. Music had probably some survival benefits for our ancestors, but this is not necessarily true for us today. Further, if music and language share some common origins, this implies that music possibly was not created to solve survival problems. Additionally, Dougherty (2006) noted that if Mithen’s (2005) assumption about “Hmmmmm” is correct and music evolved as a part of a kind of “Proto-language” then music is probably just a byproduct and not a separate adaptation.

In contrast Mithen (2005) noted that music could not only be a spin-off from language without biological value. We probably do not have any emotions for free or only for fun, because they are important to human thought and behavior, and have a long evolutionary history.

Additionally Fitch (2006) insists that the theory of music as a byproduct sounds implausible because of its age, nearly 40.000 years, and because of the richness of musical behavior in humans. Music is a costly behavior, because it is loud and so it is possible to attract predators, and it is energetically expensive. If music has no benefits, he assumes that it would not have been evolved.

2.4 Discussing adaptation and byproduct

The important question of why music evolved, has led to considerable scientific discussion of whether music evolved as adaptation or rather as byproduct of something different.

This discussion started with Darwin (1871), who suggested that music is a biological adaptation, caused by sexual selection. According to him, the adaptive function is courtship display. Brown and colleagues (2000) agreed with Darwin that music has different functions in cultures and so must be a multifunctional adaptation.

Adaptations by definition are inherited and reliable developed characteristics evolved by natural selection because they helped to solve survival and reproductive problems. Does music solve survival and reproductive problems in animals? For example, birds sing because they want to attract a partner or defend their territory. This is also reported by Darwin (1871). If we compare this fact with the explanation of adaptation, it seemed that singing in birds is an adaptation, because the prerequisites for singing in birds are inherited and all songbirds have a syrinx and the ability to learn singing. It is also a reliable developed characteristic, because all individuals of a species of songbirds are able to learn singing. Further, singing helps them to solve survival and reproductive problems. But is this also the case in humans? Pinker (1997) mentioned that musical expertise varies across peoples and cultures. Is it possible that all humans learn to make music, or are there people cannot carry a tune? But this question refers back to the definition of music. If we look at the anatomical prerequisites for singing in humans, then all people have the ability to sing. But this does not mean to carry a tune correctly. This should mean that each of us is able to learn to sing. If this is the case, singing is an inherited and reliable characteristic.

But did music solve survival and reproductive problems? Darwin (1871) concluded that the primary benefits of music are reproductive ones, which could be explained by sexual selection. If we agree with Darwin, music has to be an adaptation. But Miller (2000) noted that nobody ever found any survival benefits for music-making by individuals. He supports his argument with the example of Jimi Hendrix, who had a lot of affairs with women, but died young. So music may have given Jimi Hendrix a reproductive benefit, but he died young, which probably leads to the conclusion, that music does not give him any survival benefit. According to Mithen (2005), his sexual attractiveness could maybe be the results of other features, like good looks or being an antiestablishment figure. This is not a very good argument for sexual selection. That prominent people, like Jimi Hendrix, have so many liaisons with women has nothing to do with their ability to make music. There are other factors, like media and promotion, that gave him the opportunity to have so many affairs.

Miller (2000) notes that music has costs, because music is a loud signal that could attract predators and competitors. It is also the case that our ancestors, to dance, needed energetic bodies and had to practice and perform for hours. So it was probably the case that females choose males who could dance better and longer than other males, because this shows that they have more energy and that they are better hunters. They also would probably choose males that are able to sing louder than the others and put themselves in danger. These could be signals of higher fitness. If this is the case then music may have reproductive benefits after all. This leads again to the conclusion that music is an adaptation caused by sexual selection, because it solves reproductive problems.

Mithen (2005) argued that probably the production of stone tools, was done as social display. The chipping on the stone, during production of a stone tool, could be the first sign of rhythm production. This could also lead to the conclusion that females choose males accordingly to the rhythm they produced during chipping on the stone tool. This also could be a sign of solving a reproductive problem.

On the contrary, Fitch (2006) argued that music perception and singing develop very early in human babies, but sexually selected traits usually do not develop until sexual maturity. Furthermore, Fitch (2006) and Huron (2001) stated that music shows no signs for sexual dimorphism, because both sexes have the same ability to produce and perceive music. No example of sexual selection without sexual dimorphism is known. These two important arguments would disqualify the possibility that music is evolved, because of sexual selection. Additionally, nobody has ever claimed to find any sexual dimorphisms in music. But in birds, where everybody is sure that singing is caused by sexual selection, it seems also possible that sexual dimorphism in not present in some of the species. That only male birds sing seems to be a historical misunderstanding. Laparoscopic sexing makes it possible to figure out that especially in tropic species, female singing is very common. In such species, where both sexes are singing, no musical sexual dimorphism is present. But does this qualify music and singing from evolving through sexual selection in birds? If this fact does not disqualify music and singing from evolving through sexual selection in birds, that should be also the case for the origins of music in humans.

Sexual selection is not the only possible explanation. Music could be developed by group selection. It could be possible that in our ancestors the group size grew so large that physical grooming, which is standard in primates, replaced by “vocal grooming”. In large groups grooming would be inefficient, because a lot of time is needed, and there would be no time for other things, like reproduction. So Aiello and Dunbar (1993) postulated that language and perhaps music as well were developed out of the need for a more efficient way to groom. Falk (2009) mentioned that singing together allows social bonding and probably enables feelings similar to grooming. It could be possible that during singing together endorphins are released. Also, during music-making the hormone oxytocine is released, which is also propagated as a kind of social bonding hormone. (Freeman, 2000; Mithen, 2005)

An argument by Merker (1999) is that in primate groups, females leave the group where they were born and join another group for mating. So it could be possible that males of a group synchronize their calls in a way to make them louder in order to attract females over a wider range. The problem with this approach is that such a behavior is not found in any living primate species or any other mammals. Instead, this behavior is mainly found in insects (Mithen, 2005; Morley, 2002). So the argument of Merker (1999) is weak. This probably does not disqualify this theory, but if such a behavior is not found in any other mammal or primate, the possibility that this theory is correct is low.

According to Mithen (2005), music is cooperation without risk. If a member of a group does not take part in the singing or dancing of the group, the other members do not lose anything. This leads to the result that free-riders are not able to exploit the situation. This could be a hint for the possibility that music evolved, because of group selection. Further he argues that humans today who live in poverty make music to enable social bonding and this could possibly make it easier to help each other. This argument probably is a little weak. Today not only poor people make music together.

Yet another possibility is introduced by Mithen (2005), who compared music with food and sex. As I mentioned, some chapters above people today eat more and have more sex than they need. They do those things often just for enjoyment. But their adaptive functions still exist. This could be the same with music, because music could have had the adaptive function of group bonding in our ancestors. Today, as with food and sex, we make more music than biologically required and also just for enjoyment. But this does not mean that music is no adaptation. It still has an adaptive function – group bonding.

In contrast, Miller (2000) argued that it is unlikely that music is a result of group selection, because that would not explain the development of any other trait in a mammalian species. That music is performed in groups does not argue that it is caused by group selection. But his argument that scientists favored this theory, because it is a "kinder, gentler, more cooperative, more humane form of evolution than individual selection", is weak.

Geissmann (2000), on the other hand, mentioned that hominid music could be important to display and reinforce the bonding of a group, as shown today in military songs and national hymns. These kinds of music hint at some social-bonding function in human music. People who meet together in football stadiums and cheer on their favorite team experience some kind of social bonding. So this function, which is also seen today, could possibly also been there in our ancestors. This is also seen in the context of the supernatural. People sing in churches to praise their god. Parishes often have strong social bonding and help others, who are member of the church. Possibly the singing together enables these strong bonding mechanisms, as Nettl (1983) argues. But this could also be a result of together believing in the supernatural and not caused by making music together.

Table 1: Comparing the arguments for sexual, group and kin selection
+ = pro argumentation
– = contra argumentation

Source	Sexual selection	Group selection	Kin selection
Aiello & Dunbar, 1993		+	
Brown, 2000		+	
Darwin, 1871	+		
Dissanayake, 2000	–		
Falk, 2009	–	+	
Fitch, 2006	–	–	+
Geissmann, 2000	–	+	
Huron, 2001	–	+	
Merker, 1999		+	
Miller, 2000	+	–	–
Mithen, 2005	+	+	

Another argument that music evolved as a result of group selection is mentioned by Huron (2001), who compared people that suffered from Williams syndrome and Asperger autism. People with Williams syndrome have high musicality and high sociability. In contrast, people, who suffered from Asperger autism, have low musicality and low sociability. According to Huron (2001) this could be an advice for a connection between musicality and sociability and that could be also an evidence for a connection between music and group selection. But this connection could also evolved only by accident. This argumentation need to be tested by more data.

A further argument is introduced by Fitch (2006), who believed that music is caused by the process of kin selection, that has been mistaken for group selection, because groups are often made up of closely related kin. But this argument is implausible, because if a group is only made up of closely related kin, they have a high possibility for inbreeding. This again would damage the genetic material of the group. If this should be the case, someday this group would die out.

To get a better overview of which scientist argued for which selection theory that caused the evolution of music look at Table 1.

Pinker (1997) does not believe that music is an adaptation. He argued that music is a byproduct that borrows some of its mechanisms from other domains, like language. This would be the case if music evolved as product of a kind of "Protolanguage". If music evolved out of the development from a kind of "Protolanguage" to language, it should be a byproduct. But to know that we have to know which came first, language or music. Here it is also very important to know the differences between language and music.

Table 2: Comparing the arguments for adaptation and byproduct
+ = pro argumentation
– = contra argumentation

Source	Adaptation	Byproduct
Brown et al., 2000	+	
Cross, 2001	+	–
Darwin, 1871	+	
Dougherty, 2006	–	+
Fitch, 2005	+	
McDermott & Hauser, 2005, 2003	+	+
Mithen, 2005	+	–
Pinker, 1997	–	+
Vaneechoutte and Skoyles, 1998	+	

Pinker's (1997) argumentation that music is useless seems implausible. Music might have some functions that benefit the reproduction of an individual, as we saw above. We do not know what would happen if music disappeared from our species. This fact needs to be tested, instead of merely stated. It might be the case that music in our ancestors has an adaptive function, and today it might be that it is just a byproduct of language, having lost all its adaptive functions. So it might rather be an "exaptation" (Gould & Vrba, 1982).

The objection of Cross (2001) is also legitimate: Pinker (1997) does not include music of other cultures than the western one. If we look at traditional cultures, we might find adaptive functions of music. To get a better overview of the arguments for the adaptation and byproduct theory, look at Table 2.

2.5 Evolutionary concepts

The next consideration is, whether music evolved analogously or homologously. If music is an analogous trait, it has to be evolving independently in different species. In contrast, if music is a homologous trait, it represents descent from a common ancestor. This I will explore in the next three sections.

2.5.1 Analogy

Analogous traits are by definition, similar traits in two species that arose twice. How does one argue against like this? From pointing out similarity without descent. Fitch, for instance, notes that learning of chanting in humans and in birds is similar, as both involve complex learned vocalization. As Charles Darwin (1871) said, the last common ancestor of humans and birds, a Palaeozoic reptile, could not sing, so singing must have evolved independently in humans and birds.

Hauser and McDermott (2003) noted that animals indeed sing, but their singing is to be seen only in a limited context and exclusively in some adaptive role, for example, defending territory or impressing a potential partner. Even if animal song should influence the emotions of the listeners, Hauser and McDermott (2003) insist, they simply serve a communicational purpose (without any intention of solo-performance, or to make music for pure pleasure). Certainly humans use music to communicate, but also as pure pleasure. Another difference between humans and animals is that in animals music is only a behavior in males, but with humans, females also make music.

In contrary Fitch (2006) argued that animal song does take place outside of the limited context described above. Also human music is limited in many cultures, for example songs or styles which are exclusive for weddings, funerals or birthday parties. Young male songbirds do indeed show solo-performance, when they practice for later adult performances – thus is called “subsong”. Also, adult birds do sometimes sing alone, when they perform a so called “whisper song”. According to Fitch (2006) the reason of “pure enjoyment” is a proximate causal explanation and “communicative function” an ultimate adaptive explanation, which put together two different levels of biological explanation.

Slater (2000) assumed that any similarity between humans and birds is analogous and not homologous, because humans have to share a musical ancestor with other singing animals. Our closest relatives, great apes, communicate more by gestures and facial expression and not by sound. Humans, like whales and songbirds, are able to learn sound from other individuals. So singing behavior evolved separately in different animal groups. In humans, this could be in the relatively recent past, after the common ancestor that we shared with chimpanzees died out.

Further, Fitch (2006) noted that there are no singing primates except humans: no evidence for vocal learning of complex vocalizations in any nonhuman primate. So music has to be analogous, because the common ancestor we shared with nonhuman primates could not sing.

Another argument against Hauser and McDermott (2003) is that in animals singing is mostly a male behavior, but in humans, women do indeed sing. But as Fitch (2006) argued, there are many bird species in which females sing as much as males (he refers to Langmore (1998) and Riebel (2003)). Further, in some human cultures musical performances are limited only to males, see Titon and colleagues (1984). Another argument of Fitch (2006) is that, if only males sing in animals, this would not disqualify the theory of an analogous development. In some insect species only males have wings, but nobody would reject the analogy between these male winged insects and other ones.

2.5.2 Homology

Homologous traits are similarities between two species because of descent from a common ancestor. From studies with rhesus monkeys and other species, Hauser (2000) concludes that several components of human musical capacity have been there for a long time and that some of them possibly evolved independently several times by convergent evolution. But in primates it seems that the similarities with humans represent homology, which is shared by a common ancestor. So music is a homologous development in primates and humans.

Hauser and McDermott (2003) review a study on rhesus monkeys by Wright and colleagues (2000). They trained two rhesus monkeys to react to an auditory stimulus. The monkeys hear different short melodies and as comparison the same melodies transposed to a different pitch. They wanted to figure out, if the monkeys are able to recognize these melodies as the same ones. They found that the rhesus monkeys showed “octave generalization”. The monkeys could figure out that the transposed melody is the same as the original when transposed by one or two octaves. But this was only the case when the melodies were taken from a diatonic scale. That does not work, if the melodies were taken from an atonal scale. For Hauser and McDermott (2003) this is evidence for “innate constraints on music perception”. This phenomenon could not be found in songbirds. This phenomenon, Hauser and McDermott (2003) suggests, evolved after the split of birds and mammals. So this could represent an argument for homology. But they noted that this result could depend on the exposure of the rhesus monkeys to Western music.

Furthermore, Hauser (2000) argues that studies of cortical physiology have shown that possible fundamental units of human language, for example phonemes or words, evolved from a homologous nonhuman primate ancestor. He refers to MacNeilage (1994), who mentioned that “syllables evolved from primate lip smacks and other mandibular cyclicities associated with vocal production”.

According to McDermott and Hauser (2003), the ability to make music can’t be homologous, because no singing apes exist, and so our last common ancestor could not be able to sing. Further any similarity is more to be analogous than homologous, because humans perhaps shared a common ancestor with other singing animals (Hauser, 2000). But there are no singing primates, except humans, because no ape or monkey shows complex learned vocalization, even if some primate calls traditionally termed song, like gibbons or indris (Fitch, 2006).

On contrary, Fitch (2006) argues, bimanual drumming in great apes could be a homologue to human instrumental music. This possibly evolved after our split from orangutans and gibbons. According to him, drumming is rare in vertebrates; two other examples are woodpeckers or some rodent species.

Loud calls in modern apes and music in humans evolved from an ancestral form of loud calls. So music of early hominids had had the same functions as loud calls of apes, for example "territorial advertisement, intergroup intimidation and spacing, announcing the precise locality of specific individuals, food sources, or danger, and strengthening intragroup cohesion". (Geissmann, 2000)

Merker (2000) suggests, as mentioned earlier, that synchronous chorusing evolved, because males of a group would attract females from neighboring territories. They synchronize their calls, because they would maximize the "summed amplitude of the multivoice display", to get louder and reach a greater area with their calls. Migrating females are able to decide, which group to join, because the synchronized calls give an advice about the resources of the group and the male cooperation. Further Merker (2000) assumed that this mechanism was evolved in a common ancestor with we shared with chimpanzees. Today this form of synchronicity is shown in our preference to join in and entrain to a repetitive beat. But this preference is not seen in chimpanzees. They are not able to keep time. According to Merker (2000) this preference is possibly seen in bonobos.

2.5.3 Discussing analogy and homology

The next question arising: is music a product of analogy or of homology? If it is an analogous trait, it has to have arisen twice in different species. Fitch (2006) concluded that human music is analogous to bird song, because both are complex, learned vocalizations. It is nearly certain that the shared common ancestor between humans and birds, probably a reptile, could not sing. But here to say, we do not know it. On the other hand, there are no other reptiles, which have a complex, learned vocalization. In this case, human music has to be analogous to birdsong.

But this argument is correct only if we see music as “complex learned vocalization”. Complex vocalizations are also seen in gibbons (Geissmann, 2000) , but these vocalizations are not learned. If it is the case that these vocalizations are also some kind of music, then we have to have a common ancestor with gibbons, who make some kind of music or “Protomusic”, and music is homologous to gibbon song.

Table 3: Comparing the arguments for analogy and homology
+ = pro argumentation
– = contra argumentation

Source	Analogy	Homology
Darwin, 1871	+	
Fitch, 2006	+	
Geissmann, 2000	–	+
Hauser, 2000	+/–	+/–
McDermott & Hauser, 2003	+/–	+/–
Merker, 2000		+
Slater, 2000	+	–

Further McDermott and Hauser (2003) argued that singing in animals occurs only in a limited context and exclusively in some adaptive role. The only reason for which animals make music is to communicate, but they do not show any solo-performance. On the contrary, Fitch (2006) argues that birds indeed show solo-performance during practicing for later adult performances. McDermott and Hauser (2003) also mentioned that birds do not sing for pure pleasure, but humans indeed sing for that reason. But do we know this about birds?

We see from anatomical prerequisites and archaeological evidence that the ability to produce and perceive music and language evolved first in *Homo er-*

gaster. If the common ancestor of humans and chimpanzee was able to produce some kind of singing, why do our ancestors before *Homo ergaster*, not show any evidence of music or language? In this case, we have to say that singing evolved independently in different species. For an overview of the scientists' views, look at Table 3.

3 Materials and Methods

As we see in the previous chapters, there is a broad discussion about the evolution of music. There are diverse arguments in the literature and very few experiments on humans. Most of the scientists only talk about animals like birds and apes. In the chapters above we further discover that there is only a little sense of direction in the arguments. These scientists often do not try to support inference through research. How, to get then, clarity about the evolution of music in humans?

The first step is to analyze previous investigations, get an overview of the current state of research and the different arguments across different fields and scientists. So my work here has identified the relations, gaps, contradictions and inconsistencies in the literature and the scientific arguments that might lead to the next answered questions about the evolution of music in humans.

The last step is to compare all these different aspects for adaptation in terms of different possible selection mechanisms, along with the byproduct hypothesis. I will also compare systematically the different aspects for homology and analogy.

I used the literature I found by searching databases like “Google scholar”, “Science direct” and “Scopus”. I have used keywords like “evolution of music”, “music origins”, “music and adaptation”, “music and byproduct, “music and sexual selection”, “music and group selection”, “music and analogy”, “music and homology”, “definition of music”, “animals and music”, and so on. Since there is a lot of literature on this topic, I suppose it is possible that I have overlooked important works, but I hope not. In this case I would appreciate it if readers would bring them to my attention.

But then why not write a research article, think of an experiment, collect data and come to a conclusion? As Platt (1964) noted, that step would be premature. Before we can plan experiments, we have to collect and analyze the existing views in the literature and the various hypotheses scientists have already enunciated about the evolutionary background of music. As a result I focus on providing all major developments of the evolution of music and building bridges between all the specialized fields that are engaged with the origins of music. At the close I call for future experiments and tests of assumptions concerning the evolution of music.

4 Conclusion

The question about the evolution of music is unsettled even today. Many points reviewed above are still open and unanswered or subject to disputes.

What function does human music have? Is it a product of courtship display, of social bonding, or both? Or is music more likely to be a product of sexual, kin or group selection or even a byproduct of other cognitive domains, than an adaptation?

I showed in the chapters above that most scientists argue that music is an adaptation caused by group selection, not a byproduct. Fewer scientists argue that music is caused by sexual selection; most of them are against this hypothesis. The same is the case for kin selection. Additionally they argue for analogy and against homology. But this does not actually show that one argument is true and the other false.

As you see in Table 4, the scientists are using different bodies of evidence to describe their theories. Most of them use animals for their argumentation. Others use human adults, human children or prehistoric evidence. So it is difficult to compare their arguments because each could be right in its context. But these argumentations also have to be tested in other contexts. For example an argumentation that is based on animals, should be reconsidered in a context with human adults or children. If the argument makes no sense there, it can be excluded.

Development of human behaviors often is not for just a single reason. There are usually more reasons and this should be considered.

We see only one universal in music: lullabies. They are found around the world in every culture. These seem a plausible origin of music in humans. They are different from other songs and all babies around the world love them. Furthermore, adults communicate with infants in a special way called “motherese”. This way is also universal in all cultures. “Motherese” is a kind of musical way to communicate with infants, which evolved because the helplessness of infants increased in early hominids.

This universal in human music could be a very important clue for the evolution of music. All people around the world and in every culture speak in this manner with infants. It also hints that some components of music probably are innate. In this case it would be interesting if all people around the world are able to learn music abilities.

Table 4: What kind of evidence scientists are using

Source	Animal	Human adult	Human child	Prehistoric
Aiello & Dunbar, 1993				+
Brown, 2000				+
Cross, 2000		+		
Darwin, 1871	+			
Dissanayake, 2000			+	
Dougherty, 2000		+		
Falk, 2009			+	
Fitch, 2006	+			
Geissmann, 2000	+			
Hauser, 2000	+			
Huron, 2001		+		
McDermott & Hauser, 2003, 2005	+			
Merker, 1999	+			
Miller, 2000		+		
Mithen, 2005				+
Pinker, 1997		+		
Slater, 2000	+			

It is not straightforward to get an answer for the question of the origins of music in humans at this time. There are a lot of open aspects at this moment. There have been very few experiments on the evolution of music and thus hardly any actual data available in biological science.

4.1 FoxP2

One field of biological science has been almost completely missing in this discussion – the molecular sciences. Lai (2001) reported the discovery of the FoxP2 gene. Some members of the KE family have severe impairments in the selection and sequencing of fine orofacial movements, which are important for articulation. Also, these people have deficits in several facets of language processing and grammatical skills.

Teramitsu et al. (2004) noted that the affected individuals have a core deficit in complex coordinated orofacial movements. This includes speech, which requires procedural learning. This fact makes evolutionary study of FoxP2 of great interest, mainly in the context of the capacity for vocal learning.

Teramitsu's team identified the cDNA sequence for the songbird FoxP2, which is homologous to its role in the zebra finch. This species is interesting because only male individuals sing a courtship song. The brain regions which are responsible for this behavior, are much smaller or missing completely in females. (This fact is also interesting because in humans females do indeed sing.)

It is also very interesting that the FoxP genes are expressed in regions of the zebra finch's *dorsal thalamic zone* that are homologous to the *nucleus centrum medianum thalami* and *nucleus parafascicularis thalami* in mammals. These thalamic nuclei are hypothesized to present "attention-specific sensory information important for conditioned responses" in primates. (Teramitsu, et al., 2004)

Another interesting point is that affected members of the KE family display no problems with musical pitch and intonation, yet are impaired when producing or perceiving rhythms. (Teramitsu, et al., 2004)

Mithen (2005) notes that there are only three differences between the seven hundred amino acids of the FoxP2 in mice and humans. Enard and colleagues (2002) encoded the FoxP2 gene of chimpanzee, gorilla, orangutan and rhesus-macaque and reported that this version of the FoxP2 gene only differs in two amino acids from the version of humans. They suggest that this difference was very important for the development of speech and language in humans. According to them the gene became fixed in the population by natural selection following random mutations. This form of the FoxP2 gene accompanied the origin of modern humans, probably during the last 200.000 years.

Maybe at last we can settle this question of analogy versus homology with more data from the FoxP2 gene.

4.2 Future ideas

The next important step is to get more data about the origin of music. It would be very important to get one universal definition of music. Probably it would be possible to make some analyses of frequencies or get more data about the processing of music in the brain. Furthermore, there has to be a differentiation between music and language. Without such a differentiation it seems very difficult to get an answer on the question of music origins.

The starting point of the evolution of music should be better delimited. The period of time between 1.75 million years and 40.000 years ago is a very long one. It is important to get a shorter time span here, probably with analyses of more fossil records.

The origins of music are much discussed since Charles Darwin in 1871, but it seems as if today this discussion is still at the very beginning. Scientists have to find a way to test their concepts about the evolution of music. We need to go well past sterile arguments about definitions, and try to understand how music came to be such a universal aspect of being humans with such different functions in infancy and adulthood.

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